

Chapter 6

VERTICAL OBSERVATION (VERT OBS) DATA

INTRODUCTION

The purpose of this chapter is to provide detailed specifications and instructions for the coding and keying of the observation data set of a vertical control job. As was explained in Chapter 5, a vertical control job consists of two distinct data sets which must be submitted together. The companion data set to the vertical observation (VERT OBS) data set treated in this chapter is the data set containing original descriptions and/or recovery descriptions for the control points which occur in the vertical control job. This descriptive (VERT DESC) data set is treated in Chapter 7.

VERT OBS DATA SET RECORDS

The data which constitute a VERT OBS data set are organized into four categories:

1. Line Identification Data
2. Survey Equipment Data
3. Field Abstract Data
4. Observation Data

Within these categories, the respective data have been grouped into one or more logical units called "records." A record is a string of characters containing data coded according to a specific format. Every record in a VERT OBS data set consists of 80 characters or "columns" (standard punched card image). Within each record, the 80 columns are divided into fixed-length "character fields," each field being the space reserved for a specific data item. Accordingly, for every desired data item, there exists a field of appropriate length into which the data item in question is to be entered after it is converted into a string of alphanumeric characters. The set of rules according to which specific data items are converted into strings of alphanumeric characters to be entered in the fields of a record is known as the "format" of that record.

The types of records which may appear in a VERT OBS data set are listed in Table 6-1. Each type of record has been given a name, and a block diagram illustrating the respective format has been prepared to serve as a model for that record - see FORMAT DIAGRAMS.

Except for the first and last records of the data set, the second character field of each record (columns 7-10) contains a two-digit numerical data code, preceded and followed by an asterisk, which specifies the type of that record (*10*, *11*, ..., *43* - see Table 6-1). The first and last records of the data set (the Data Set Identification Record and the Data Set Termination Record) display the two-character alphanumeric job code assigned by the submitting agency in this field (*A1*, *A2*, ..., *ZZ* - see Chapter 5). The first character field of every record (columns 1-6) is reserved for the respective record sequence number - see Chapter 5. The remaining portion of each record (columns 11-80) contains character fields which are peculiar to each individual record type.

TABLE 6-1
VERTICAL OBSERVATION DATA SET RECORDS

FIRST RECORD

AA - Data Set Identification Record

LINE IDENTIFICATION DATA

10 - Line Information Record
 11 - Line Title Record (Optional)
 12 - Line Title Continuation Record (Optional)
 13 - Line Title Continuation Record (Optional)
 14 - Line Title Continuation Record (Optional)
 15 - Comment Record (Optional)

SURVEY EQUIPMENT DATA

20 - Instrument Information Record
 21 - Rod Information Record
 22 - Rod Standardization Record
 23 - Rod Calibration Record

FIELD ABSTRACT DATA

30 - Field Abstract Record

OBSERVATION DATA

40 - Survey Equipment Record
 41 - Running Record
 42 - River/Valley Crossing Record
 43 - Correction/Rejection Record

LAST RECORD

AA - Data Set Termination Record

Note: The symbol *AA* denotes the two-character job code assigned by the submitting agency - see Chapter 5.

STRUCTURE OF THE VERT OBS DATA SET

The first record of a VERT OBS data set must be the Data Set Identification Record which contains the required information to identify the data set and to correlate it with its companion VERT DESC data set - job code, data type (VERT OBS), name of submitting agency, and date the data set was created. The last record of the data set must be the Data Set Termination Record. It is the only other record in the data set on which the respective job code appears in the same field (columns 7-10) as on the Data Set Identification Record.

The VERT OBS data set records which are bracketed by these two delimiting records may pertain to one or more units of field work; i.e., field observation data for several leveling lines may be submitted in one VERT OBS data set under the same job code, provided that the total number of survey points (bench marks and temporary bench marks) in the job does not exceed 9,999 (see Chapter 5). When two or more leveling lines are included in a vertical control job, each line must appear as a complete unit in the respective VERT OBS data set, i.e., as a block of records which contains all information pertinent to that line (see table 6-2). Each line must begin with a *10* record, contain any appropriate number of the other types of records in proper sequence, followed by one or more *40* - series records.

TABLE 6-2
STRUCTURE OF THE VERT OBS DATA SET

Data Set Identification Record	
10-series records	FIRST LINE
20-series records (if any)	
30 records	
40-series records	
10-series records	SECOND LINE
20-series records (if any)	
30 records	
40-series records	
::::	::::
::::	::::
10-series records	LAST LINE
20-series records (if any)	
30 records	
40-series records	
Data Set Termination Record	

A leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks - see Chapter 5) which are connected by chains of differential leveling observations called "runnings." When coded as part of a VERT OBS data set, a leveling line is a block of records comprising record groups arranged in the following order:

1. Line Identification Data (*10*-Series) Records:

- *10* record
- *11* record (optional; possibly *12*, *13*, and *14* records as well)
- *15* records (optional, any number allowed)

2. Survey Equipment Data (*20*-Series) Records:

- *20* records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) for the first instrument used
- *20* records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) for the second instrument used
- ::::
- *20* records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) for the last instrument used
- *21*, *22*, and/or *23* record(s) - *21* record alone if rod not previously reported and no standardization or calibration data are available; in general, one *21* record followed by one or more *22* records (one for each previously unreported rod standardization), one or more *22*, *23*, ..., *23* record sets (one such set for each previously unreported single-temperature rod calibration), and/or one or more *23*, *23*, ..., *23* record sets (one such set for each previously unreported multiple-temperature rod calibration with one or more *23* record(s) for each calibration temperature) - for the first rod used
- *21*, *22*, and/or *23* record(s) - *21* record alone if rod not previously reported and no standardization or calibration data are available; in general, one *21* record followed by one or more *22* records (one for each previously unreported rod standardization), one or more *22*, *23*, ..., *23* record sets (one such set for each previously unreported single-temperature rod calibration), and/or one or more *23*, *23*, ..., *23* record sets (one such set for each previously unreported multiple-temperature rod calibration with one or more *23* record(s) for each calibration temperature) - for the second rod used
- ::::
- *21*, *22*, and/or *23* record(s) - *21* record alone if rod not

previously reported and no standardization or calibration data are available; in general, one *21* record followed by one or more *22* records (one for each previously unreported rod standardization), one or more *22*, *23*, ..., *23* record sets (one such set for each previously reported single-temperature rod calibration), and/or one or more *23*, *23*, ..., *23* record sets (one such set for each previously unreported multiple-temperature rod calibration with one or more *23* record(s) for each calibration temperature) - for the last rod used

Note that for instruments and/or rods which are used in more than one leveling line submitted in the same or in different vertical control jobs, it is not necessary to repeat the same *20*-series records in each such line or each such VERT OBS data set. It is sufficient to submit the respective *20*-series records once as part of the first line submitted in which such instruments and/or rods appear, and thereafter only if the stadia factor is redetermined for an instrument and/or if a rod is restandardized or recalibrated - see SURVEY EQUIPMENT DATA RECORDS.

3. Field Abstract Data (*30*) Records:

30 records - one for the first (starting) survey point (bench mark or temporary bench mark) followed by one *30* record for each elevation carried forward to a survey point along the leveling line.

The order of the *30* records is important; normally they should follow in sequence as the respective survey points (bench marks and temporary bench marks) occur along the leveling line. However, one or more spurs may emanate from any given survey point - in which case, after the *30* record for such a "base" point, the *30* records for all survey points along the longest spur must follow first, then those along the next-longest spur, etc. Only when all spurs emanating from that base point have thus been exhausted, should the *30* record for the elevation carried forward to the next survey point along the main route be given - see example in Figure 6-1.

In the absence of any closed loops, there will be as many *30* records as there are survey points along the leveling line. However, if a loop is closed (as in the case of a spur loop or if the line itself forms a closed loop), an additional *30* record must appear in proper sequence (see above) for the endpoint of every such loop, reflecting the elevation carried forward to that bench mark or temporary bench mark via the loop.

4. Observation Data (*40*-Series) Records:

40 record giving the date, instrument/rod combination, and
collimation error data for the first set of runnings
41 record for the first running in the first set
43 record (if needed) for the first running in the first set
41 record for the second running in the first set
43 record (if needed) for the second running in the first set
::::
41 record for the last running in the first set
43 record (if needed) for the last running in the first set
40 record giving the date, instrument/rod combination, and collimation
error data for the second set of runnings
41 record for the first running in the second set
43 record (if needed) for the first running in the second set
41 record for the second running in the second set
43 record (if needed) for the second running in the second set
::::
41 record for the last running in the second set
43 record (if needed) for the last running in the second set
::::

40 record giving the data, instrument/rod combination, and collimation
error data for the last set of runnings
41 record for the first running in the last set
43 record (if needed) for the first running in the last set
41 record for the second running in the last set
43 record (if needed) for the second running in the last set
::::
41 record for the last running in the last set
43 record (if needed) for the last running in the last set
42 record for the first river/valley crossing along the line
43 record (if needed) for the first river/valley crossing along line
42 record for the second river/valley crossing along the line
43 record (if needed) for the second river/valley crossing along line
::::
42 record for the last river/valley crossing along the line
43 record (if needed) for the last river/valley crossing along line

LINE IDENTIFICATION DATA RECORDS

10 Line Information Record
11 Line Title Record (Optional)
12 Line Title Continuation Record (Optional)
13 Line Title Continuation Record (Optional)
14 Line Title Continuation Record (Optional)
15 Comment Record (Optional)

The line identification data records, bearing the *10*-series data codes, are listed above; the block diagrams illustrating the respective formats will be found under FORMAT DIAGRAMS.

The *10* record contains essential line identification data and is always required. The *11* record is optional; however, it is highly desirable that a line title (reflecting the geographic location of the line - see below) be given. The line title should be concise so as to fit on the *11* record (up to 70 characters); however, one, two, or three continuation records (the *12*, *13*, and *14* records) may be appended if the title is lengthy or if a main title followed by subtitle(s) is called for. Following the *11* record (or else the last title continuation record), there may appear as many *15* records as appropriate to give comments pertinent to the leveling line (e.g., significant problems encountered, deviations from standard procedures, etc.), if any.

The entries on these records (see FORMAT DIAGRAMS) are for the most part self-explanatory; however, the following data items will be explained in greater detail:

Leveling Line: As was stated in the preceding section, a leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks) which are connected by chains of differential leveling observations called "runnings." Each segment of a leveling line consisting of two neighboring survey points connected by a running is called a "section" of the leveling line.

The objective of differential leveling is the extension of vertical control by precise determination of differences of elevation between successive survey points along the leveling line. The end product is a string of permanently marked vertical control points or bench marks (BMs).

Tolerance Factor: To control the accumulation of error in the differential leveling process, each section of a leveling line is normally "double-run," i.e., observed twice by runnings in opposite directions, and the disagreement between the respective differences of elevation as determined by the two runnings must not exceed a tolerance limit computed as the product of the appropriate tolerance factor and the square root of the section length.

Aside from the units of measurement involved, the numerical value of the tolerance factor used for this purpose depends on the type and intended accuracy of the vertical control survey in question; it is one of the specification parameters which characterizes a given order and class of vertical control survey (see below).

Note that the tolerance factor is expressed in mixed units, i.e., in "Units of Elevation Difference Disagreement Per Square-Root of Units of Section Length." For the purposes of this publication two such unit combinations are allowed (must be specified by the respective units code given as part of the tolerance factor data group on the *10* record):

1. Millimeters per square-root of kilometers (units code MM), and
2. Feet per square-root of statute miles (units code FT).

Order and Class of Survey: A two-digit code is provided on the *10* record to specify the order of accuracy of the survey. The first digit of this code reflects the order and the second digit the class of the survey in accordance with the "Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys," prepared by the Federal Geodetic Control Committee (FGCC), and published by the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, Rockville, MD (February 1974). In addition to the five vertical control survey categories defined in this publication, three other survey categories need to be considered - old vertical control surveys of first or second order for which no class is specified, and surveys of lower-than-third-order accuracy. The respective two-digit codes are as follows:

- 10 - First-Order (Class Unspecified)
- 11 - First-Order, Class I
- 12 - First-Order, Class II
- 20 - Second-Order (Class Unspecified)
- 21 - Second-Order, Class I
- 22 - Second-Order, Class II
- 30 - Third-Order
- 40 - Lower-Than-Third-Order

not used

Remove this
classification
in next
revision

The order-and-class code assigned to a leveling line should reflect the procedures and specifications according to which that entire line has been observed. When well-defined segments of a leveling line fall into different order-and-class categories, the line must be divided accordingly and the respective parts submitted as separate lines.

State or Country Code: Provision is made on the *10* record to indicate the political unit(s) and/or geographic area(s) in which the leveling line is located using the two-letter state or country codes given in ANNEX A. Up to three such codes may be entered, in the order of progress along the line in question. In the United States or in Canada, enter the appropriate code for the respective state, commonwealth, province, or territory; elsewhere enter the appropriate code for the respective country, island group, or geographic area - see ANNEX A.

Line Title: The desired elements of information in the title of a leveling line are (1) the respective line number or other identification symbol, (2) the order of accuracy of the survey, (3) whether original leveling or releveling, and (4) the geographic locality (or localities) of the survey. Since the first three elements are explicitly coded on the *10* Line Information Record (see FORMAT DIAGRAMS), it would be superfluous to repeat them in the line title, and hence only the geographic location needs to be specified. The use of geographic location alone as the title of a leveling line has traditionally been the practice of the NGS and its predecessors.

In general, the title by which the leveling line is known to the submitting agency should be given, supplemented to reflect geographic location, as required. Omit punctuation marks (periods, commas, etc.) and parentheses whenever their omission can be tolerated, and use ANNEX A state and country codes whenever reference to a state or country is necessary. Furthermore, edit and/or abbreviate the line title in the interest of fitting the entire title on the *11* Line Title Record, if at all possible. However, up to three additional records (the *12*, *13*, and *14* Line Title Continuation Records) may follow the *11* Line Title Record if the title must be lengthy or when a main title followed by one or more subtitles is desired.

The geographic location of the leveling line should be descriptive of the route followed, i.e., the starting locality, any prominent "via" points, and the ending locality should be specified in the order of progress of the survey (Example: ALBANY GA VIA MORVEN TO CALLAHAN FL). If the leveling line is a member of a special project or of an area network to which a specific name or title has been assigned, such a name or title should be carried as a main title on the *11* record and the title of the line proper should follow as a subtitle on one or more of the continuation records. Example:

11 Record: TULARE-VASCO ARVIN-MARICOPA AREA CA
12 Record: 9.1 KM SE OF KETTLEMAN CITY TO PIXLEY .

DATE AND TIME

Date of the VERT OBS data set creation must appear on the Data Set Identification Record, and the dates on which survey operations commenced and terminated are to be entered on the *10* Line Information Record. In addition, character fields are reserved for the date and/or time on several other records of the VERT OBS data set. Throughout the VERT OBS data set, date and time are to be coded as follows:

Date: Full date is coded as an eight-digit integer number consisting of four two-digit groups denoting (from left to right) the last whole century, number of full years since the turn of century, month of the year, and day of the month (CCYYMMDD). For the 20th

century, the "century" columns may be omitted, and the date coded as a six-digit integer number denoting the year, month, and day (YYMMDD). If the day is not known (e.g., in connection with old data extracted from archives for which the date is not fully specified), leave the last two columns of the field blank; if the month is not known, leave the last four columns of the field blank. For example, February 8, 1970, would be coded as follows:

- | | | | |
|------------------------------------|----------|----|--------|
| 1. Full date is known: | 19700208 | or | 700208 |
| 2. Day of the month is not known: | 197002 | or | 7002 |
| 3. Month of the year is not known: | 1970 | or | 70 |

Time: The time of day is coded as a four-digit integer number consisting of two two-digit groups denoting (from left to right) the hours and minutes (HHMM) of a 24-hour clock. Each four-character time field or pair of (beginning and ending) time fields is preceded by a one-character field reserved for the appropriate one-letter U.S. Navy time zone designation (see below). In every case, the local zone time is to be used; in this manner ambiguities are avoided concerning the date, which is always assumed to be the "local" date (i.e., the date changes at local midnight).

Time Zone: A time zone is a geographic region in which uniform time differing by an integer number of hours from Greenwich Mean Time (GMT) is maintained by law. In theory, a time zone extends 7-1/2 degrees in longitude east and west of a "time meridian" whose longitude is a multiple of 15 degrees (since the Earth rotates 360 degrees in 24 hours, 15 degrees of longitude difference equals one hour of time difference). In practice, the lines which separate adjacent time zones often follow political boundaries and are therefore irregular. Associated with every time zone is a "time zone description" - an integer number positive west of Greenwich and negative east of Greenwich - which represents the number of hours which must be added (algebraically) to the local zone time in order to obtain the corresponding GMT. The time zone description is reduced by one hour when the standard zone time is changed to daylight-saving time.

Instead of the numeric time zone description, it is more convenient to use the U.S. Navy one-letter codes which uniquely identify each time zone. In this system, GMT is the "Z" (Zulu) Time Zone. Time zones east of Greenwich are identified by letters A, B, C, etc., through L, with the letter J omitted. Time zones west of Greenwich are identified by letters N, O, P, etc., through X. The letter Y is used to designate the western half of the time zone centered on the meridian of longitude 180 degrees (International Date Line), and the letter M is used to designate the eastern half of this zone.

The world-wide use of the time zone descriptions and the U.S. Navy one-letter designations is illustrated in ANNEX H. In the continental

United States, Alaska (AK), and Hawaii (HI) the time zones are as given in Table 6-3:

TABLE 6-3 - U.S. NAVY TIME ZONE DESIGNATIONS

<u>STANDARD TIME</u>	<u>DAYLIGHT TIME</u>	<u>TIME MERIDIAN</u>	<u>TIME ZONE DESCRIP'N</u>	<u>U.S. NAVY DESIGNATION</u>
Atlantic AST	Eastern EDT	60W	+4	Q (Quebec)
Eastern EST	Central CDT	75W	+5	R (Romeo)
Central CST	Mountain MDT	90W	+6	S (Sierra)
Mountain MST	Pacific PDT	105W	+7	T (Tango)
Pacific PST	Yukon YDT	120W	+8	U (Uniform)
Yukon YST	AK/HI HDT	135W	+9	V (Victor)
AK/HI HST	Bering BDT	150W	+10	W (Whiskey)

If the time zone cannot be reliably ascertained, leave the time zone field blank. In this case, the time given will be interpreted as the standard time in a zone determined on the basis of the longitude of the vertical control point from which the respective leveling observations (running) originate. As of this printing, Arizona, Hawaii, eastern Indiana, Puerto Rico, the Virgin Islands, and American Samoa do not observe daylight savings time. Verify locally (during the time of observations) whether or not daylight savings time is in effect.

SURVEY EQUIPMENT DATA RECORDS

- *20* Instrument Information Record
- *21* Rod Information Record
- *22* Rod Standardization Record
- *23* Rod Calibration Record

The survey equipment data records, identified by *20*-series data codes, are listed above; the block diagrams illustrating the respective formats are given in the FORMAT DIAGRAMS. The survey equipment data records contain identification and calibration data pertaining to the leveling instruments and rods used to carry out the differential leveling observations. See STRUCTURE OF THE VERT OBS DATA SET for the proper sequence in which the *20*-series records must appear in the block of records which constitutes a leveling line in a VERT OBS data set.

The *20* Instrument Information Record contains the data required to identify a leveling instrument (the appropriate NGS survey equipment code and the instrument serial number), date of stadia factor determination, and the stadia factor itself. This stadia factor will be used in the computation of the lengths of sights made with that instrument subsequent to the respective stadia factor determination date. Several *20* records may be submitted as a group for a leveling instrument; one for each past stadia factor determination.

The *21* Rod Information Record contains analogous data (the appropriate NGS survey equipment code and the rod serial number) required to identify a leveling rod; however, it does not contain any calibration data. Rod calibration data, which are required only for rods used in first- and second-order differential leveling work, must follow the *21* record in the form of a *22* record, a record set consisting of a *22* record and one or more *23* record(s), or a record set consisting of two or more *23* records, all bearing the same standardization/calibration date.

Again, several such *22* records, *22*, *23*,..., *23* record sets, and/or record sets of the form *23*, *23*,..., *23*, as appropriate, may be submitted as a group for a leveling rod following the respective *21* Rod Information Record; one such *22* record, *22*, *23*,..., *23* record set, or *23*, *23*,..., *23* record set for each past calibration of the leveling rod in question.

The *22* Rod Standardization Record contains the summary of a rod calibration. For the purposes of this chapter, the term "standardization" will be used to denote a group of data which is the end product of a rod calibration (i.e., the respective coefficient of thermal expansion, rod excess, and index error - see below). The *22* Rod Standardization Record may appear alone, or it may be followed by one or more *23* Rod Calibration Record(s) containing the (single-temperature) calibration data on which the standardization summary is based. Optionally, a *22* record may also precede a set of two or more *23* records of a multiple-temperature calibration; in this case, however, all data contained on the leading *22* record are inferable from the accompanying *23* records.

The *23* Rod Calibration Record contains data pertaining to the calibration of a leveling rod at one temperature. For single-temperature calibrations, submit one or more *23* record(s) following the corresponding *22* record (see above) - as many as required to accommodate all calibration intervals (three per *23* record - see FORMAT DIAGRAMS). For multiple-temperature calibrations, submit a set of *23* records (one or more per calibration temperature), with or without a preceding *22* record, which is optional in this case. In general, *23* Rod Calibration Records should be submitted whenever the respective data are available.

NGS Leveling Instrument and Rod File: The purpose of the *20*-series records is to provide input to a permanent computer file in which a historic record is maintained for each leveling instrument and leveling rod ever used in a VERT OBS data set submitted to the National Geodetic Survey. A record is established in this file for an instrument or rod at the first time it is encountered in the processing of a VERT OBS data set. Thereafter, the file is updated by adding new information to the respective instrument and/or rod records whenever

standardization or calibration data not previously available are encountered among the *20*-series records of a subsequently processed leveling line in the same or different VERT OBS data set.

Accordingly, it is not necessary to repeat identical *20* Instrument Information Records among the *20*-series records of every leveling line in which that instrument appears. It is sufficient, for any instrument, to submit one or more such records (one for each past determination of the respective stadia factor) once initially, and thereafter only when a new stadia factor is determined (e.g., following the installation of a new reticle). Of course, for each leveling line, care must be taken to insure that any omitted *20* Instrument Information Records have previously been made available for inclusion in the NGS Leveling Instrument and Rod File.

Analogously, it is not necessary to repeat identical *21* Rod Information Records, *22* Rod Standardization Records, and/or *23* Rod Calibration Records among the *20*-series records of every leveling line in which the respective rod appears. It is sufficient, for any rod, to submit an appropriate grouping of these records (covering all past calibrations) only once initially, and thereafter only when the leveling rod in question is recalibrated. Again, in connection with every leveling line, care must be taken to insure that any omitted *21*, *22*, and/or *23* records have previously been made available for inclusion in the NGS Leveling Instrument and Rod File.

To summarize, submit a *20* record for every previously unreported leveling instrument and/or previously unreported stadia factor determination. For every leveling rod, submit a *21* record alone if the rod has not previously been reported and no calibration data follow (e.g., a rod used in third- or lower-order differential leveling work exclusively). Otherwise, submit (as a group) one *21* record followed by one or more *22* records, one or more *22*, *23*,..., *23* record sets, and/or one or more *23*, *23*,..., *23* record sets, as appropriate; one such *22* record, *22*, *23*,..., *23* record set, or *23*, *23*,..., *23* record set for each previously unreported calibration of the leveling rod in question.

NGS Survey Equipment Code: A three-digit numeric identification code assigned to each category of survey equipment, and within each category to specific instruments or other commonly used items. In particular, leveling instruments are assigned 200-series survey equipment codes, while leveling rods and staves are assigned 300-series survey equipment codes (see ANNEX F).

Instrument/Rod Serial Number: Assigned by the manufacturer, the serial number is the ultimate identifier of a specific leveling instrument or leveling rod. Serial numbers are normally numeric;

however, alphabetic characters are often used as prefixes, suffixes, etc., and special characters such as a blank (space), hyphen (minus sign), slash (solidus), etc., may appear imbedded in the respective alphanumeric character group. For this reason, a serial number must be treated as alphanumeric information to be entered in the respective character field left-justified and blank-filled on the right.

The instrument or rod serial number will be used together with the respective survey equipment code (see above) to create appropriate entries in the NGS Leveling Instrument and Rod File, to maintain these entries up to date, and to access this file for the retrieval of the respective stadia factor and/or rod calibration data in the course of routine processing of VERT OBS data sets. It is therefore of utmost importance that the respective serial number be faithfully reproduced as given by the manufacturer, character for character, including any leading zeros, imbedded blanks, etc., and that identical serial number representation be used consistently whenever reference is made to that specific instrument or rod in any VERT OBS data set.

Stadia Factor: An instrument-specific constant numerically equal to the ratio of the focal length of the instrument to the respective stadia interval, i.e., to the distance which separates the stadia lines (two horizontal lines spaced equally above and below the level line) in the reticle of the leveling instrument. By design, the stadia interval is chosen so that the stadia factor is a convenient integer number such as 100.

The stadia factor is used to obtain the distance between the leveling instrument and a rod as the product of the stadia factor multiplied by the respective (full) stadia intercept - see OBSERVATION DATA RECORDS. Note that a sight length so obtained is in the same units as the stadia intercept, i.e., in rod units, and hence must be further multiplied by a conversion factor to obtain the sight length in other units.

Rod Units: The units in which the respective rod scale is graduated. Four different rod units are acceptable, each identified by a two-letter code. They are as follows:

- CF - centifeet (0.01 ft)
- CM - centimeters (0.01 m = 1 cm)
- CY - centiyards (0.01 yd = 0.03 ft)
- HC - half-centimeters (0.005 m = 0.5 cm = 5 mm)

Rod Graduation Code: A one-digit code denoting the type of graduation of the respective leveling rod:

- 1 - line graduation (single scale)
- 2 - line graduation (double scale)
- 3 - block graduation (including checkerboard)
- 4 - other

Temperature Scale: The temperature at which the leveling rod was calibrated must be given on both the *22* Rod Standardization Record (Standardization Temperature) and the *23* Rod Calibration Record (Calibration Temperature). On either record, provision is made to indicate which of the two possible temperature scales applies by means of a one-letter code immediately preceding the respective temperature field:

C - Celsius Temperature Scale
F - Fahrenheit Temperature Scale

Coefficient of Expansion: The relative change in linear dimension (expansion or contraction) per unit of temperature change peculiar to the material of the respective leveling rod scale (these include INVAR or other low-expansion metal alloys for modern rods, and specially treated wood for rods used in older differential leveling work of high precision). Aside from the scale factor 10,000 mentioned below, the coefficient of expansion given on the *22* Rod Standardization Record must be in units which are compatible with the respective temperature scale and rod units (see above), as specified in Table 6-4.

TABLE 6-4
UNITS OF COEFFICIENT OF EXPANSION

ROD UNITS	TEMPERATURE SCALE	
	C	F
CF	feet per degree Celsius	feet per degree Fahrenheit
CM	meters per degree Celsius	meters per degree Fahrenheit
CY	feet per degree Celsius	feet per degree Fahrenheit
HC	meters per degree Celsius	meters per degree Fahrenheit

The coefficient of expansion expressed in either one of the four possible unit combinations (see above) is always a very small decimal fraction. To avoid the keying of a long string of zeros preceding the first significant digit, enter the respective coefficient of expansion multiplied by 10,000, i.e., with the decimal point moved four places to the right (Example: A coefficient of expansion of 0.00000079 is entered as 0.0079 or .0079).

A-Flag: Enter 'A' if the coefficient of expansion (see above) is an "assumed" value (i.e., as given by the manufacturer, or a standard value for the material in question). Leave the field blank if the coefficient of expansion has been determined by means of a multiple-temperature calibration of the respective leveling rod.

Rod Excess: A factor used to compute the rod correction for a single running of a section of a leveling line. The rod calibration process precisely determines the actual length of the respective rod (or of a representative segment thereof). Rod excess is the ratio of the difference between the actual and nominal length (actual minus nominal) to the nominal length of the rod (or calibrated segment thereof).

Note that the rod excess is a unitless number; however, since it is always a small (positive or negative) decimal fraction, it is convenient to express rod excess as the aforementioned ratio multiplied by 1,000 (i.e., as millimeters per meter, if metric units are being used). Accordingly, regardless of the respective rod units, enter the rod excess with the decimal point moved three places to the right.

Index Error: The distance above or below the bottom surface (foot) of the leveling rod at which the nominal origin (zero) of the respective graduated scale is located (the origin of the low scale of a rod with a double-scale graduation). The index error is positive when the scale origin falls below the foot of the rod; it is negative when the scale origin falls above the foot of the rod. Note that the index error is expressed in rod units (see above) of the leveling rod in question.

FIELD ABSTRACT DATA RECORDS

***30* Field Abstract Record**

The purpose of the *30* record is to provide cross-reference between the primary identifier (i.e., the designation) of a vertical control point and the corresponding job-specific survey point serial number (SPSN). In addition, the accumulated distance along the leveling line and the respective "field" elevation (see below) are given on this record. Following established practice, these latter two data items are computed from the detailed differential leveling field notes as the work progresses and are normally recorded on a form called the "Field Abstract" - hence the name "Field Abstract Record." The block diagram illustrating the respective format will be found with the **FORMAT DIAGRAMS**.

Submit a *30* record for the first (starting) survey point (bench mark or temporary bench mark), followed by a *30* record for each elevation carried forward to a survey point by the differential leveling process. Normally, in the absence of any closed loops, there will be as many